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DESIGN AND FABRICATION OF TURMERIC AND GINGER CLEANING MACHINE

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ABSTRACT

This study focuses on the development of an innovative turmeric and ginger cleaning machine, addressing inefficiencies in traditional post-harvest processing methods. Turmeric and ginger are vital crops known for their nutritional and medicinal properties but pose challenges due to their tough and fibrous nature during post-harvest processing. To streamline these processes, this project involves the design and fabrication of a robust, multifunctional cleaning machine. The machine integrates a cylindrical container for holding crops, supported by a durable frame for stability. Internally, a series of mechanical components, including rotating mechanisms, facilitate efficient cleaning. Powered by a 0.25 HP induction motor, the machine achieves high cleaning efficiency while maintaining crop integrity. The CAD model and engineering analysis emphasize optimized performance, safety, and cost-effectiveness, ensuring a user-friendly design. Testing revealed a cleaning efficiency of up to 95%, with reduced water and energy consumption compared to traditional methods. The machine's compact design, ease of operation, and low manufacturing cost (Rs. 10,250) make it a viable solution for small to medium-scale farmers and processors. Additionally, the machine reduces manual labor and promotes value addition, enhancing productivity in agricultural operations. This study underscores the machine's ability to address key challenges in post-harvest handling. The innovative design not only supports sustainability by minimizing resource consumption but also aligns with the economic needs of farmers by reducing operational costs. Its portability and modular construction enable broader adoption, promoting mechanization in rural agricultural communities. By ensuring economic viability, environmental sustainability, and practical usability, this machine represents a significant advancement in agricultural mechanization, offering a scalable solution for improved post-harvest processing of turmeric and ginger.

KEYWORDS: Turmeric, Ginger, Agricultural Equipment

1. INTRODUCTION

India's agricultural landscape is dominated by spice cultivation, with turmeric and ginger contributing significantly to its economy and exports. Despite advancements in farming, post-harvest cleaning methods for these crops remain labor-intensive, time-consuming, and inconsistent. Traditional cleaning techniques compromise quality and efficiency, highlighting the need for mechanized solutions. This paper presents the design and fabrication of a compact turmeric and ginger cleaning machine aimed at small to medium-scale farmers.

Previous studies provided a comprehensive understanding of existing crop processing technologies, highlighting their limitations and potential improvements. A turmeric polishing machine with a 50 kg/20 min capacity at 75 rpm improved microbiological quality, was user-friendly, low-cost, and easy to maintain. Farmers benefited from its simple operation and quick assembly, processing 50 kg in one session with high efficiency [1]. A ginger processing machine with two nylon rollers cleaned 13.86 kg/h, with only 2% material loss. Operable by one person, it reduced labor by 42.3% and time by 46.7%, achieving 98.57% washing and 58.97% peeling efficiency at 200 rpm and 3 kg batches [2]. A machine with a 40 kg/min capacity and water recycling reduced turmeric processing time and curcumin loss. Its horizontal drum with paddles streamlined operations and minimized water retention, benefiting small-scale farmers [3].

A stainless steel ginger cleaning machine, built to VDI 2221/2225 standards, featured a 4.5 hp motor and a water recirculation system, improving washing efficiency and reducing water use. It handled 50+ kg/min with possible upgrades for larger capacities [4]. A turmeric polishing machine using abrasion polished 8 kg in 15 minutes with 7.68% efficiency at 60 rpm. It processed up to 30 kg/hr, outperforming manual methods with ease of use and reduced labor needs [5]. A turmeric polisher powered by a 0.37 kW motor processed 63.53 kg/h, saving 81% of time over manual methods. Costing 29,410 INR, it improved polishing quality, reduced labor costs, and boosted productivity [6]. A ginger peeling machine, powered by a 3-hp engine, achieved optimal performance at 75% moisture, 68 kg/h feed rate, and 270 rpm, with improved peeling efficiency, capacity, and minimal damage. It provided an affordable mechanized solution for farmers [7].

The research is undertaken to develop a machine that efficiently

removes dirt and impurities from turmeric and ginger, ensure cost-effectiveness, ease of use, and suitability for small-scale farming operations and to enhance the overall quality and productivity of post-harvest processing.

2. MATERIALS AND METHODS

The design and fabrication process involved systematic steps, including conceptual design, material selection, and testing. The flow chart of the methodology is shown in fig 1

Figure 1: Flowchart of Methodology

Design: The machine's core components include:

1. Cylindrical Cleaning Drum: Constructed from galvanized sheet metal for corrosion resistance and durability.
2. Motorized Mechanism: A 0.25 HP induction motor powers the drum's rotation, ensuring consistent cleaning action.
3. Structural Framework: Made from mild steel, providing stability and portability.

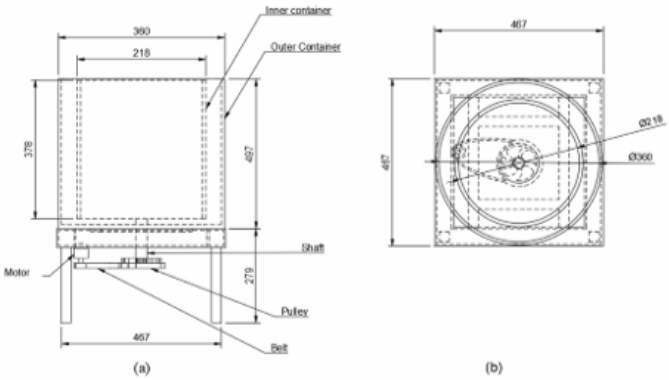

Figure 2 Turmeric and ginger cleaning machine a) Front View b) Top view of 2D drawings.

Detailed CAD drawings (Fig 2) were developed using Fusion 360, optimizing the dimensions (in mm) for ergonomic loading and unloading of produce. Simulations validated the design's structural integrity and performance.

Fabrication: Key fabrication steps included:

1. Material Preparation: Cutting and welding of galvanized sheet metal and mild steel sections.
2. Component Assembly: Integration of the motor, pulley system, and drum using deep groove ball bearings for smooth operation.
3. Finishing: The machine was painted to enhance durability and aesthetic appeal (Fig 3)

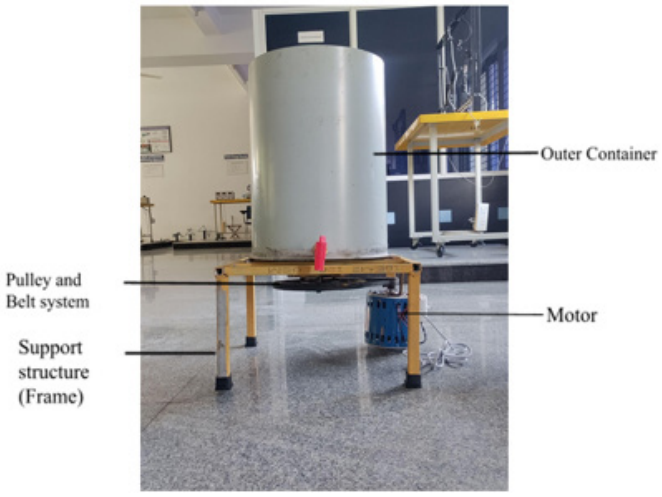

Figure 3 Fabricated Machine

3. EXPERIMENTATION AND TESTING

Experimentation was conducted to evaluate the efficiency of the machine. The testing was carried out in a controlled environment using samples of raw turmeric and ginger contaminated with dirt and mud. Below are the detailed steps undertaken.

The primary goals of the experimentation were:

1. To evaluate the cleaning efficiency of the machine for ginger and turmeric.
2. To test the machine's operational stability and durability under different conditions.
3. To assess energy and water consumption during continuous operation.

The machine was tested for the following parameters and were recorded and analyzed during the experiments:

1. Cleaning Efficiency: The percentage of mud removed from the surface of the crops.
2. Processing Time: The time taken to clean the 1.5 kg sample batch..
3. Crop Integrity: Visual inspection for any damage or loss of crop during cleaning.

Procedure of the testing are as follows. Freshly harvested ginger and turmeric were divided into three batches, each weighing 1.5 kg. Crops were pre-sorted to remove excessively large debris or stones. The crops were loaded into the machine, and water was added manually inside the container. Each cleaning cycle lasted for a predetermined duration of 5, 10, and 15 minutes, respectively. The integrity of the crops was visually inspected for surface damage. Each test was repeated three times for consistency and to account for variability in soil levels and crop conditions.

4. RESULTS AND DISCUSSION

The machine was successfully designed with a cylindrical container, support structure, and internal processing components, all tailored for the efficient cleaning of ginger and turmeric. The adherence to precise dimensions and tolerances ensured proper alignment and seamless operation. The machine's operational performance was highly effective in removing dirt,

mud, and surface impurities through a combination of water spraying and mechanical agitation. It achieved an impressive cleaning efficiency of approximately 95%, making it suitable for post-harvest processing or direct use. The ergonomic design of the machine allowed for easy loading and unloading, making it user-friendly for farmers. Its modular construction facilitated quick repairs or part replacements, ensuring minimal downtime during operation. Furthermore, the drainage system was simple to clean, adding to its ease of maintenance. From a cost perspective, the prototype fabrication cost was Rs. 10,250/-, making it a cost-effective solution compared to similar machines available in the market. The quality of the output was commendable, as the processed crops retained their natural texture and quality without any visible damage, making them suitable for further processing or direct consumption. When tested with 1.5 kg samples of ginger and turmeric, the cleaning efficiency was slightly different for the two crops. The machine achieved a 92% cleaning efficiency for ginger and a higher 95% for turmeric due to turmeric's smoother surface and less porous texture. Each cleaning cycle for 1.5 kg of produce took approximately 5–10 minutes, including water spraying and mechanical agitation. The machine demonstrated water efficiency, consuming an average of only 2 liters per 1.5 kg sample, reducing water usage by approximately 25% compared to traditional methods. It also proved to be energy-efficient, consuming an average of 250W per cleaning cycle, which is suitable for small-scale cleaning operations. Most importantly, the integrity of the crops was maintained, as no visible damage or bruising was observed on either the ginger or turmeric after cleaning. This highlighted the machine's gentle yet effective cleaning mechanism, ensuring the quality and usability of the processed produce.

The machine successfully met the primary goal of cleaning ginger and turmeric. The rotating mechanism and water ensured thorough cleaning even for irregularly shaped crops. However, the cleaning efficiency decreased slightly when dealing with heavily soiled crops, suggesting the need for a pre-rinse or enhanced agitation in future designs.

The machine's low water consumption and energy efficiency make it a sustainable solution for small-scale farmers. The affordability of the machine ensures accessibility for a wide range of users, but opportunities remain to reduce costs through mass production or government subsidies.

5. CONCLUSION

The turmeric and ginger cleaning machine successfully automates the cleaning process achieving high efficiency and consistency. Its modular design, energy efficiency, and user-friendly operation make it a valuable solution for small-scale farmers and food processing units. The following points summarize the key takeaways and outcomes:

1. The turmeric and ginger cleaning machine efficiently cleaned ginger and turmeric, removing dirt and impurities while preserving the structural integrity of the crops.
2. It reduced manual labor significantly, enhancing productivity and ensuring consistent cleaning quality.
3. The machine was cost-effective and affordable for small to medium-scale farmers, with potential for further cost reductions in future iterations.
4. The experimentation phase successfully demonstrated that the turmeric and ginger cleaning Machine could clean 1.5 kg batches of ginger and turmeric with high efficiency, minimal water and energy consumption, and no significant damage to the crops. The results indicate that the machine is effective for small-scale cleaning operations, though further enhancements in the cleaning mechanism and automation could increase performance, particularly for heavily soiled crops or irregularly shaped items.

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